Special Activity Utilization of GDSCC Antennas During 1981

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In addition to direct spacecraft support, the GDSCC antennas also support "special" activities. These activities can be categorized as Advanced Systems Program, Radio Astronomy Program, Crustal Dynamics Program, and Operations and Support Activities. This article briefly discusses the goals and categorizes each of the activities that received tracking support at Goldstone during 1981. All Goldstone stations (DSSs 11, 12, 13 and 14) provided a total of 2353.55 hours of support to "special" activities during the period January through December 1981.

I. Introduction

The antennas at the Goldstone Deep Space Communications Complex (GDSCC), in addition to providing telemetry, ranging, and commanding support to spacecraft projects, also support a number of other tasks which require "tracking." These special activities are categorized in this report into Advanced Systems Program, Radio Astronomy Program, Crustal Dynamics Program, and Operations and Support Activities. This report discusses the special activities which were supported with tracking by the GDSCC antennas during the period January through December, 1981.

II. Advanced Systems Program

Activities in this category are funded by NASA through the Office of Space Tracking and Data Systems (OSTDS). This is the development work which culminates in provision, to the Deep Space Network (DSN) stations, of new capability with which each spacecraft project's needs can be met. Related activities are associated and organized into Research and Technology Operations Plans (RTOPs). GDSCC activities in this category are tabulated in Table 1 with hours and stations involved.

A. RTOP 60: Radio Metric Technology Development

The goal of this effort is the development and demonstration of advanced radio metric systems for navigation and radio science, with a specific angular accuracy goal of 50 nanoradians for delta VLBI measurements.

In general, using VLBI, this RTOP generates a catalog of suitable (strength and location) extragalactic radio sources (EGRSs). Using this catalog of EGRSs, the ephemerides of the planets, particularly Mars, are tied into the "radio reference frame." Then techniques are developed for differential measurements between spacecraft and EGRSs which locate the spacecraft within the radio reference frame and hence the spacecraft with reference to the target planet(s). Table 1 lists the various activities within the RTOP for which tracking support was provided at GDSCC during 1981.

B. RTOP 65: Antenna Systems Development

In recognition of the necessity of improving antenna performance to provide increased planetary communications capability, this activity's goal is to enhance antenna technology. Specifically, this RTOP looks at possible improvements in electronic-microwave capabilities and mechanical-structural design. Application of technology to provide higher frequency operation of existing antennas, along with more sophisticated techniques of antenna pointing, is also a part of this activity.

As part of the analysis performed in this area, techniques for measurement of antenna gain were refined and used to make extensive measurements at DSS 12. These antenna gain measurements were used to quantify and evaluate the changes in microwave performance resulting from main reflector surface alignment and changes in subreflector position as a function of antenna attitude.

The particular activity supported during 1981 at DSS 13 was "Analytical Techniques and Procedures," which has as its objective the development of analysis software for application to antenna structural and mechanical performance. (An innovative application used a cooled infrared camera to obtain thermal measurements of the DSS 13 26-m antenna backup structure. These measurements supplied information on possible thermally induced structural deformations which was not heretofore available.) This activity also aims to extend the capability for automatic antenna structural design optimization and organize existing software to simplify maintenance and execution of improvements. Again, Table 1 depicts tracking support during 1981.

C. RTOP 68: Station Monitor and Control Technology

Recognizing that a substantial portion of the operating cost for DSN stations is allocated to personnel, this RTOP seeks to develop automation technology that will allow entire station operation from a remote point and prove the reliability, safety, and efficiency of unattended operation. Additionally, this RTOP plans to develop the data base with which reliability, costs, and productivity can be monitored, using DSS 13 as a demonstration unattended station.

Table 1 lists only tracking support to this activity; substantial other work was also ongoing at DSS 13 during the year as the equipment used to make DSS 13 operate in the unattended mode evolved and additional systems were added to those controlled remotely.

D. RTOP 70: High-Speed Signal Processing Research

The objective of this RTOP is to develop high-speed digital signal processing techniques for use in the DSN. A major part of this task is the development of a test bed as a research tool used to explore high-speed techniques. The test bed is to be used for demonstrations of various development capabilities, such as high-performance array processors and wideband correlation subsystems. This work also demonstrates commercial LSI signal processing building blocks and utilizes promising commercial design systems.

The particular activity supported at GDSCC during 1981 was Radar Data Acquisition, which uses various planets and asteroids as targets for demonstration of signal processing techniques.

In Table 1 are listed the various targets which were explored in 1981 as the demonstration test bed was used to develop signal processing techniques.

III. Radio Astronomy Program

In general, activities in this category are either sponsored by the Office of Space Science (OSS) or authorized by the Radio Astronomy Experiment Selection (RAES) panel.

Experimenters within NASA who desire OSS support of their activities submit an observing plan in the form of an RTOP. If approved, OSS requests OSTDS to provide support, and time is made available on suitable facilities of the DSN. Experimenters from universities who have observing plans that require NASA facilities submit their observing plan to the RAES panel. If approved, time is made available through an agreement whereby NASA makes available a percentage of the operational time on DSN facilities. Table 2 depicts the support at GDSCC in this area during 1981.

A. OSS-Sponsored Activities

1. Pulsar rotation constancy. This experiment seeks to monitor short-term variations in the period of the relatively young VELA pulsar (PSR 0833-45). Additionally, by observing 23 older, more stable pulsars, this experiment hopes to obtain data that will provide further tests of the hypothesis that pulsars are neutron stars resulting from supernova explosions, which impart high velocities to the resulting pulsar.

2. Planetary radio astronomy. This experiment has the dual objectives of studying the properties of the planet Jupiter's radio emission and measurement of the thermal emission from the atmosphere of the outer planets. A new objective is to search for a link between variations in the Io plasma Torus and Jupiter's radio emissions. These observations will aid construction of improved models of Jupiter's radiation belt environment as well as atmospheric models of the outer planets, particularly Uranus.

3. SETI Receiving System Stability Measurements. In anticipation of a SETI observing program (which never materialized), the phase and amplitude stability of the various receiving systems at DSS 14 was measured.

B. JPL Director's Discretionary Fund Sponsored Activities

1. Science utilization of the Radio Frequency Interference Surveillance Subsystem (SURFISS). As part of the task of detection and characterization of radio frequency interference, the DSN has developed a unique capability to perform high-resolution spectrum analysis. This van-mounted subsystem can perform real-time spectral analysis of a 20-MHz band of frequencies, using 2^{16} channels, resulting in a resolution of 305 Hz. The objective of this task was to develop computer programming and observing techniques which would best make use of this high-resolution, wide bandwidth capability to perform radio astronomical observations. In particular, the RFI subsystem, with altered software, would be used to observe fine structure and narrow spectral features in radio astronomical objects.

The RFI subsystem, coupled to the 26-m antenna, was used at DSS 13, to observe, among others, the H142α line in M17. This line was observed at approximately 2272.3 MHz.

C. RAES Panel Sponsored Activities

1. VLBI investigation of SS-433 (RA-175). SS-433 has a bizarre optical spectrum that exhibits three sets of emission lines. One of these three emission lines shows near-zero radial velocity, while the other two show large and variable shifts to the blue and the red. The variability is periodic, with a period of about 164 days.

This experiment conducts regular VLBI observations of this source, using many simultaneous baselines. These multiple baselines should enable determination of the source angular size and structure, which will aid modeling. These observations show that the compact radio structure is also variable, with a period of 164 days. The involved stations at GDSCC include DSS 13 and DSS 14, along with a number of other radio observatories in the United States and Europe.

2. VLBI investigation of "twin" quasistellar objects (QSOs) 0957 + 561A, B (RA 176). These QSOs, designated 0957 + 561A, B, are separated by only 6 arc seconds in angle and have equal optical redshifts and remarkable similarity in their optical spectra. This similarity is inconsistent with chance alone, so the objects are in some manner physically associated. One theory proposes that there is only one object, whose radiation is gravitationally bent about an intervening massive lens, a "gravitational lens."

This experiment uses VLBI observations with many simultaneous baselines to provide data with which detailed structure maps can be prepared. Repeated observations could monitor changes in the radio brightness distribution. At GDSCC, the involved antenna is DSS 14.

3. Milliarcsecond nuclei in quasars and galaxies (RA-177). The 64-m antennas at Goldstone, California, and Madrid, Spain, connected as a Very Long Baseline Interferometer (VLBI), have a detection sensitivity of 1 mJy at S-band and 2 mJy at X-band. This task uses this sensitive interferometer to determine the frequency of occurrence of milliarcsecond radio nuclei in radio quasars and radio galaxies. These two antennas, used in the VLBI configuration, generate detailed maps of the nuclei of these extragalactic objects. A knowledge of the statistical occurrence and properties of these nuclei will aid in a more detailed understanding of the role these nuclei play in the energetics and evolution of extragalactic objects.

IV. Crustal Dynamics Program

A Crustal Dynamics Program goal is the demonstration of the capability of VLBI systems to make highly accurate geodetic measurements. The particular activity supported at GDSCC during 1981 is Mobile VLBI Field Operations. The thrust of the Mobile VLBI activity is to demonstrate the geodetic performance of highly mobile (antenna size approximately 4 meters) VLBI stations while providing accurate data of significant geophysical interest. By moving around California and making VLBI measurements with base stations located at GDSCC, Owens Valley Radio Observatory, and other fixed points, the Mobile VLBI activity is able to accumulate data on regional deformation and strain accumulation, particularly as associated with the San Andreas Fault.

These measurements are usually scheduled for periods of 7 to 10 days, in excess of 24 hours observing at a time, and a number of suitable radio sources are observed simultaneously and repeatedly by all the stations involved. During the period January 1 through December 31, 1981, DSS 13 (Venus Station) provided 418.75 hours of tracking support to these measurements of crustal deformation along the San Andreas Fault.

V. Operations and Support Program

The maintenance of a capability to observe at various frequencies, on a routine basis, involves a number of activities which do not easily fit any of the specific programs supported at GDSCC, but these activities are essential to continued support of any or all programs. For the purposes of this progress

report, these activities are grouped under the heading "Operations and Support." These activities are tabulated in Table 3, along with hours and stations involved.

A. Antenna Boresight Offset Measurements

At DSS 13, where developmental Cassegrain feedcones are routinely used for program support, continued knowledge of the offset between the antenna mechanical axis and the antenna electromagnetic axis, as a function of antenna attitude, is essential. By use of suitable radio calibration sources, on which the antenna is "boresighted" (usually at 15-minute intervals of time), a table of axis offsets as a function of antenna attitude can be generated. This table can then be used to provide assurance of accurate "blind pointing" on objects such as weak radio sources where no real-time indication of correct pointing can be obtained.

B. High Resolution Analysis, Transmitter(s) Radiated Spectrum

As part of the overall electromagnetic compatibility program at DSCC, the actual radiated spectrum of the various transmitters at DSS 14 was measured. These measurements utilized the Department of Commerce radio frequency measuring van, coupled with the JPL developed high resolution spectrum analysis subsystem, usually referred to as the "RFI Van." Measurements were made on the 20- and 100-kW S-band transmitters and the 400-kW X-band transmitter. Partial measurements were also made on the 400-kW S-band transmitter. These measurements characterized the radiated spectrum of each of the transmitters, including carriers and associated spurious signals, with a maximum resolution of 305 Hz.

C. Precision Signal Strength Measurements, ISEE-3

Signal strength measurements of ISEE-3, made in the conventional fashion (using automatic gain control voltage as an analog of signal strength) were not of appropriate precision or resolution. Using equipment normally used for radio astronomy activities, DSS 12 and 13 made direct measurement of the power ratio in a narrow bandwidth (10 kHz nominal) with and without the spacecraft signal present. With knowledge of the receiving system temperature, the spacecraft signal strength can be accurately computed from these power ratios.

D. Electromagnetic Compatibility Testing (Sodium Lamp)

Nighttime illumination around the antennas is essential, but should be of minimum energy consumption. Sodium vapor lighting is efficient but the potential for radio frequency interference to the DSN antennas was unknown. At DSS 13, the sodium lamp, in the fired and unfired state, was positioned over the antenna feedhorn and, using specialized equipment, the possible level of interference was determined. It was concluded that lamps of this type are suitable for ground installation around DSN antennas.

E. Precision Signal Strength Measurements, ALSEP-16

Antenna gain measurements can be, and are, made using radio calibration sources. However, from time to time, it is desirable to have available a far-field source which radiates a strong, narrrow-band, stable signal. The radio transmitters left on the Moon by the Apollo astronauts are quite suitable for this purpose, but occasional characterization of the signals is necessary. These measurements were to determine the continued suitability of ALSEP-16 as a stable far-field signal source. On the DSS 13 26-m antenna, ALSEP-16 was measured at -110 dbm signal level.

F. VLBI Software Development

When performing VLBI measurements, which depend upon correlation of two (or more) signals, real-time information about proper functioning of the station is desirable. Utilizing RF signals generated at the DSS 14 antenna, modifications were made to in-use software to enhance its utility for real-time performance evaluation.

G. Antenna Location Determination, National Geodetic Survey

VLBI measurements of vector distances between participating stations require accurate knowledge of the geodetic location of a reference point on the antennas used to make these observations. On the DSS 13 antenna, this point is the intersection of the azimuth and elevation axes. Personnel from the National Geodetic Survey agency required access to the DSS 13 26-m antenna in order to tie this axis intersection into the continental grid locations. To aid these measurements, the 26-m antenna was intermittently positioned as required over a period of a few weeks.

Table 1. Advanced Systems Program utilization of GDSCC antennas during 1981

Activity	Station and tracking hours provided			
	11	12	13	14
RTOP 60 radio metric technology development				
Mark IV radio metric system development and demonstration			101.75	5.25
VLBI radio source identification			102.00	16.50
5 nanoradian VLBI system analysis and modeling			52.00	
Microwave phase delay calibration			44.75	14.25
Clock synchronization VLBI			14.25	
RTOP 65 antenna systems development				
Analytical techniques and procedures		140.75[a]	33.25	
RTOP 68 station monitor and control technology				
DSS 13 S/X unattended system development			22.50	
RTOP 70 high-speed signal processing research				
Radar data acquisition				
Asteroid Melpomene				6.00
Planet Mercury			4.25	58.00
Planet Saturn and Rings of Saturn				20.25
Callisto (satellite of Jupiter)				29.25
Totals		140.75	374.75	149.50

[a]Antenna gain measurements.

Table 2. Radio astronomy utilization of GDSCC antennas during 1981

Activity	Station and tracking hours provided			
	11	12	13	14
OSS sponsored activities				
Pulsar rotation constancy	117.00	3.25	184.75	81.00
Planetary radio astronomy			207.25	30.50
SETI receiving system stability measurements				26.50
JPL Director's Discretionary Fund sponsored activities				
Science utilization of the Radio Frequency Interference Surveillance Subsystem (SURFISS)			45.25	
RAES panel sponsored activities				
VLBI investigation of SS-433-RA 175			57.25	26.00
VLBI investigation of "twin" quasistellar objects (QSOs) 0957 + 561A, B and 1038 + 528A, B-RA 176				52.25
Milliarcsecond nuclei in quasars and galaxies-RA 177				15.50
Totals	117.00	3.25	494.50	231.50

Table 3. Station operations and associated activity utilization of GDSCC antennas during 1981

Activity	Station and tracking hours provided			
	11	12	13	14
Antenna boresight offset measurements			80.50	
High resolution analysis, transmitter(s) radiated spectrum				17.00
Precision signal strength measurements, ISEE-3		5.00	4.25	
Electromagnetic compatability testing (sodium lamp)			5.00	
Precision signal strength measurements, ALSEP-16			2.75	
VLBI software development				2.00
Antenna location determination, National Geodetic Survey			171.25	
Totals		5.00	263.75	19.00